P1.42 DATA ASSIMILATION USING WEATHER RESEARCH AND FORECASTING MODEL: AN EFFORT TO IMPROVE FINE-SCALE MODELING

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1. INTRODUCTION

The JSU Meteorology Program (JSUMP) in collaboration with the University of North Dakota (UND) and the Army Research Lab (ARL/CISD) evaluate the impact of various approaches to initialization, data assimilation and comparison of mesoscale numerical models. The models used are the NCAR/Penn State MM5 and Weather Research and Forecasting (WRF) (Grell et. al 1994 and WRF Tutorial, 2003). Special attention is placed on addressing the improvement, validation and verification of mesoscale and microscale modeling through better model initialization, solution and application of model physics to specific environments, terrain, and surface boundary layer problems. In addition, the ability to predict ground/terrain conditions and its effect on troop and vehicle mobility is of great importance to the army and in maintaining homeland security.

Battlefield operations demand precise forecasting according to weather regime and location using fine scale modeling of 1-3 km resolutions. Reliable mesoscale models provide insight on the potential effectiveness of the transport and diffusion of chemical and biological agents and support the deployment of ground and airborne assets. Data from various sources, using data assimilation techniques, fed into the atmospheric numerical model can be tuned to generate acceptable output and then incorporated into a decision support matrix. In the present study, MM5 and WRF models are run on a high performance-computing environment to simulate the severe weather event that occurred on May 3 and 4, 1999 over the Oklahoma-Kansas region.

2. EVENT HISTORY

The most expensive tornado outbreak in U.S. history and the deadliest of the year 1999 occurred on May 3 and 4 in Oklahoma and Kansas. In less than 21 hours, a total of 78 tornadoes touched down across the two states, with as many as four tornadoes from different storms on the ground at once (Figure 1).

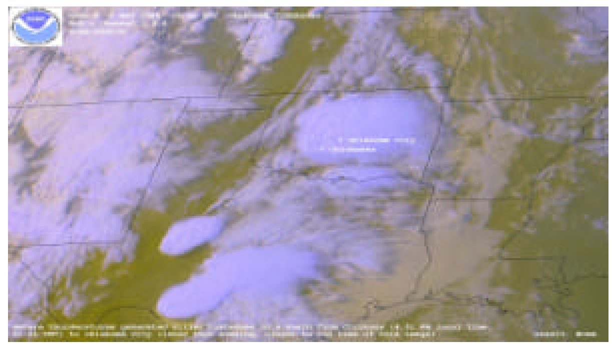

Figure 1: GOES-8 satellite imagery on May 03, 1999 at 2155Z

The event seemed to be a worst-case scenario in terms of threatening lives and property. The National Weather Service (NWS) has, thus far, identified 8 supercell thunderstorms, which produced 59 discernable tornadoes in Central Oklahoma alone. Many of these tornadoes were violent, long track, and struck cities directly, including heavily populated Oklahoma City.

3. MODEL CONFIGURATION AND METHODOLOGY

Upon applying the initialization schemes to atmospheric data within a mesoscale domain, 24 hour forecasts/simulations are made using WRF at high resolution. The case study used is determined to be of interest to army applications. Comparisons of the model performance based on the differing initializations are conducted with emphasis primarily on surface or near-surface quantities. Parameters to be considered which include surface temperature, PBL height, wind magnitude, and precipitation. Observed data sets used include observations from FAA/NWS sites,

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the Oklahoma Mesonet, and other applicable surface observing networks in order to maximize the ability to detect mesoscale features.
The MM5 model output is used to construct initial and lateral boundary conditions for the WRF run. WRF is run on height coordinate. A simple flowchart of the working is shown in Figure 2. Tables 1 and 2 show the configuration and physics used in MM5 and WRF respectively (Grell, 1993, Schultz, 1995, Kain and Fritsch, 1993).

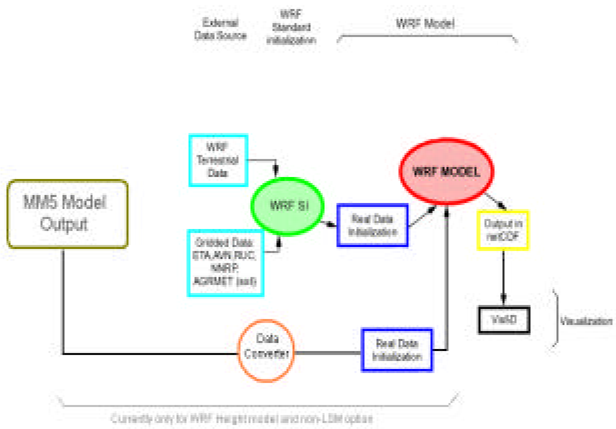

Figure 2 - MM5-WRF coupling

Dynamics	Non-hydrostatic		
High resolution	27 Km	9 Km	3 Km
Vertical Layers	23		
Forecast Time	24	24	12
Initialization	NCEP Global Analysis	2-way	2-way
Radiation Scheme	Simple		
Explicit Scheme	Simple Ice	Reisner2	Shultz
Cumulus Scheme	Grell	Grell	Kain-Fritach
PBL Scheme	MRF	MRF	Blackadar
Soil Scheme	5-layer soil		

Table 1 - MM5 Configuration

Option	Scheme
Short wave radiation	*Dudhia*
Long wave radiation	*RRTM*
Surface-layer	*Monin-Obukhov*
Land-surface	*Thermal diffusion*
Boundary-layer	*MRF*
Cumulus	*Eta Kain-Fritsch*
Microphysics	*NCEP 3-class*

Table 2 - WRF Configuration (3 Km – 24 hr period)

4. MODEL RESULTS

Figures 3 and 4 show MM5 simulations of wind magnitude and PBL height on 050399 at 2155Z. Figures 5 (a) to (f) also show MM5 simulations of precipitation and surface temperature on 050399 at 2200Z and 040499 at 00Z. Figure 6 (a) to (f) show WRF simulations of precipitation and surface temperature on 050399 at 2200Z and 040499 at 00Z that used MM5 output as model initial conditions.

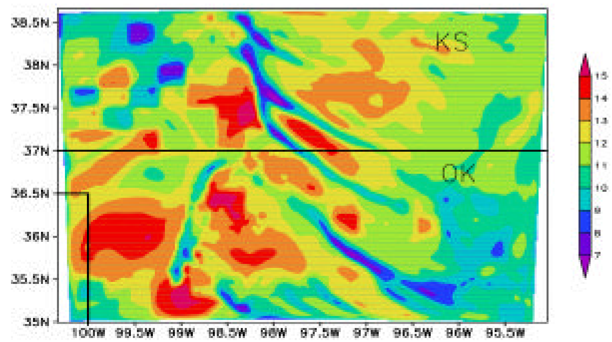

Figure 3 - MM5: Wind Magnitude (m/s) on 050399 at 2155Z

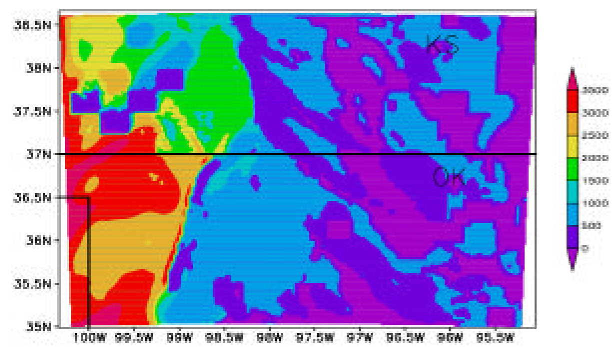

Figure 4 - MM5: PBL height (ft) on 050399 at 2155Z

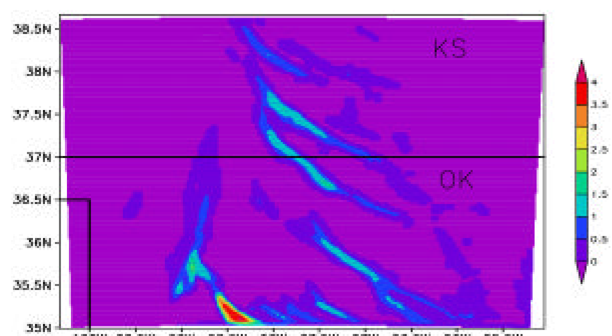

Figure 5 (a) - MM5: Total Precipitation (in) on 050399 at 2200Z

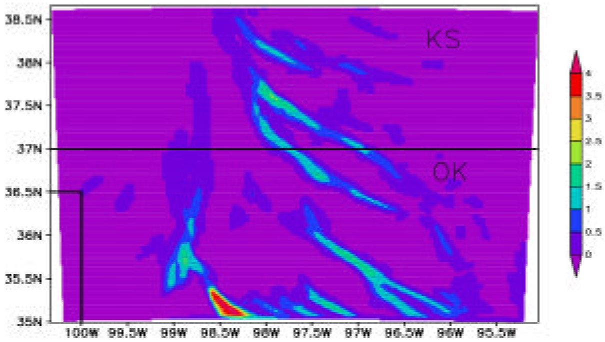

Figure 5 (b) - MM5: Total Precipitation (in) on 050399 at 2300Z

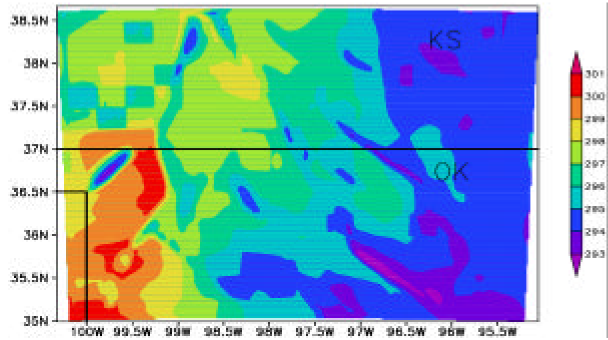

Figure 5 (f) - MM5: Surface Temperature (K) on 050499 at 00Z

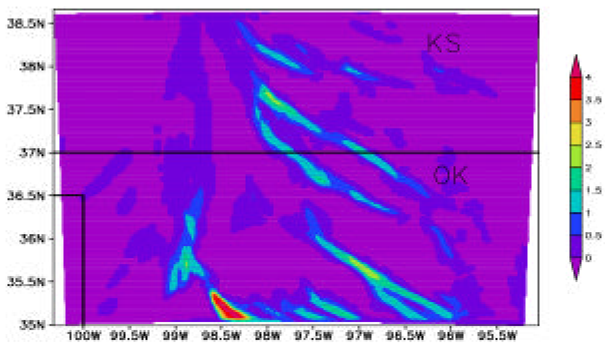

Figure 5 (c) - MM5: Total Precipitation (in) on 050499 at 00Z

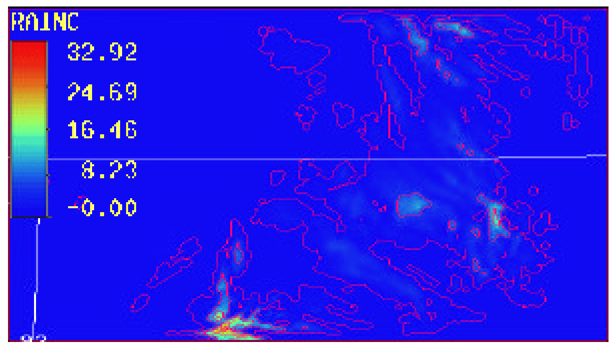

Figure 6 (a) - WRF: Total Precipitation (cm) on 050399 at 2200Z

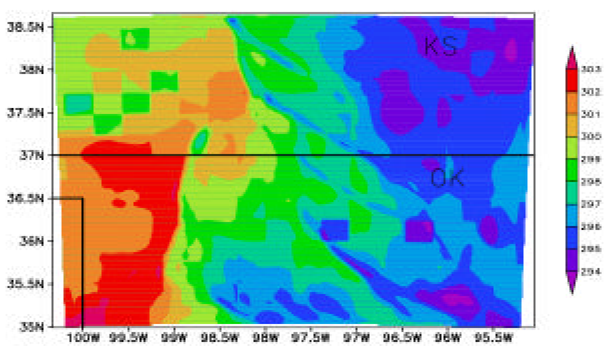

Figure 5 (d) - MM5: Surface Temperature (K) on 050399 at 2200Z

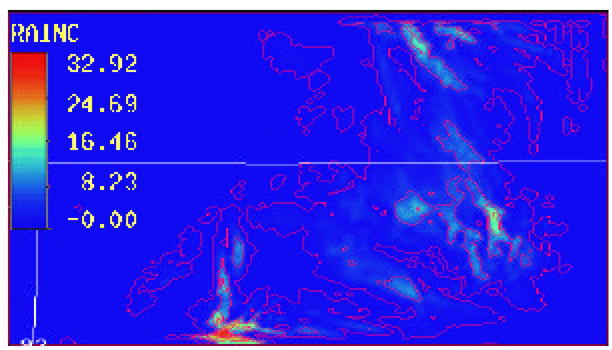

Figure 6 (b) - WRF: Total Precipitation (cm) on 050399 at 2300Z

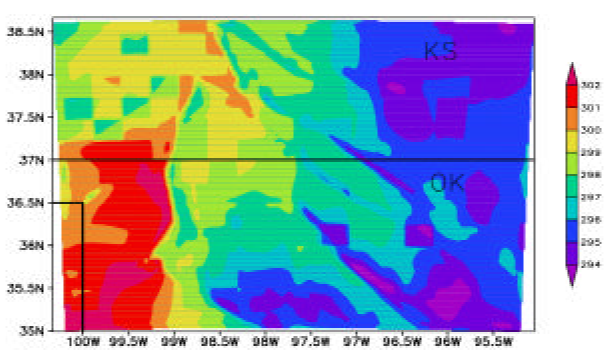

Figure 5 (e) - MM5: Surface Temperature (K) on 050399 at 2300Z

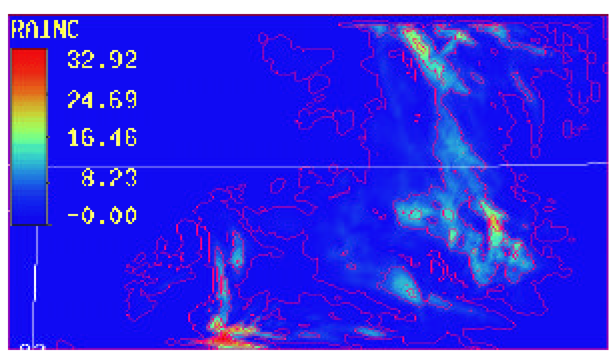

Figure 6 (c) - WRF: Total Precipitation (cm) on 050499 at 00Z

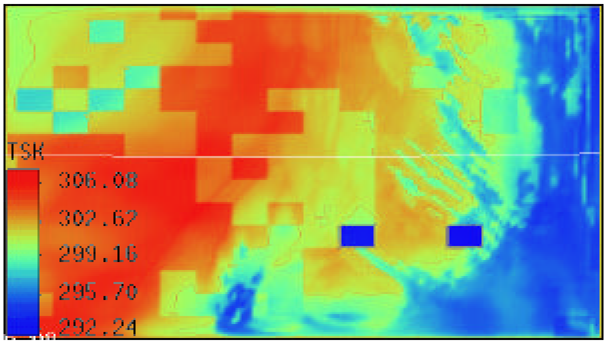

Figure 6 (d) - WRF: Surface Temperature (K) on 050399 at 2200Z

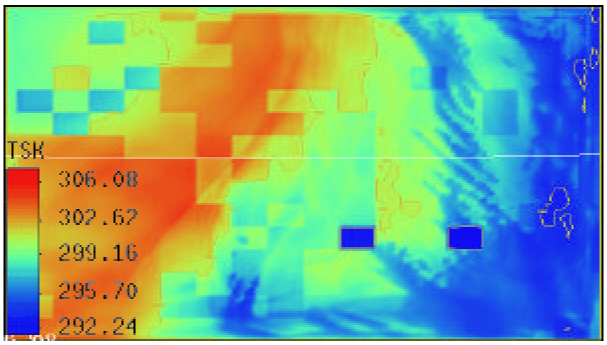

Figure 6 (e) – WRF: Surface Temperature (K) on 050399 at 2300Z

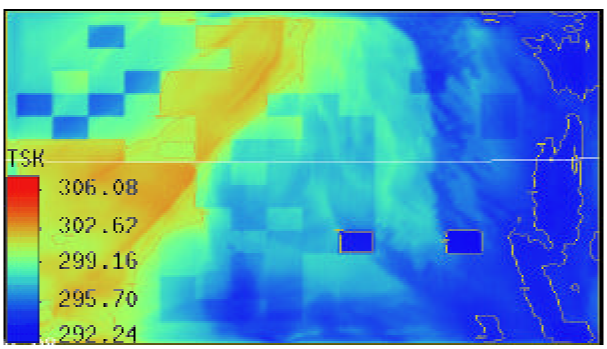

Figure 6 (f) - WRF: Surface Temperature (K) on 050499 at 00Z

5. RESULTS

- The WRF model simulations for 24-hr period forecasting have been improved by ingesting MM5 output for initial and lateral boundary conditions.
- The WRF model is capable of simulating severe weather event conditions during tornado outbreak accurately compared to MM5.
- The WRF has predicted a strong temperature gradient (14°K) at 2200Z compared to MM5 (8°K) with warmer temperatures over the southeast region. A cooling effect due to heavy precipitation has been depicted at 00Z.
- The WRF has improved in simulating wide spread total precipitation during forecast time compared to MM5. A maximum total precipitation of about 33 cm has been predicted at 2300Z and 00Z, which is close to the observations.
- MM5 predicted strong surface winds (15 m/s) on 2155Z with a strong convective PBL height over the western region.

6. FUTURE OUTLOOK

We will implement Large Eddy Simulations (LES) driven by MM5 and LAPS mean grid quantities in efforts to research WRF Boundary Layer Processes and Parameterization and compare models through verification and according to weather regime and location. Comparisons of the model performance based on the differing initializations will be conducted with emphasis primarily on surface or near-surface quantities. Parameters to be considered include air temperature, humidity, wind, pressure, precipitation, turbulence, and visibility.

7. ACKNOWLEDGEMENTS

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8. REFERENCES

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